Teletransmission of electrocardiogram in emergency medical services

(Teletransmisja elektrokardiogramu w ratownictwie medycznym)

J Wypyszewska [1,A,D], A Romaszewski [1,F,C], Z Kopański [1,2,E], M Głowacka [2,B], M Mazurek [3,B], J Rowiński [3,B,C], W Ptak [3,B]

Abstract – One of the most important elements in the process of treatment of patients in life-threatening conditions is the fastest possible acquisition of information obtained by members of the MRT through subjective and physical examination by medical staff (caring for patients in several different places). Rapid data exchange is possible thanks to the use of electronic medical documentation and its availability with the use of telemedicine systems. The authors discussed the benefits and barriers to the implementation and development of telemedicine systems in medical rescue.

Key words **-** telemedicine, medical rescue.

Streszczenie – Jednym z najistotniejszych elementów w procesie leczenia pacjentów znajdujących się w stanie zagrożenia życia jest jak najszybsze pozyskiwanie przez pracowników medycznych (opiekujących się chorym w kilku różnych miejscach) informacji uzyskanych przez członków ZRM w drodze badania podmiotowego oraz przedmiotowego. Szybka wymiana danych możliwa jest m. in. dzięki zastosowaniu elektronicznej dokumentacji medycznej oraz jej udostępnianiu przy wykorzystaniu systemów telemedycyny. Autorzy omówili korzyści i bariery dla wdrażania oraz rozwijania systemów telemedycznych w ratownictwie medycznym.

Słowa kluczowe – telemedycyna, ratownictwo medyczne.

Author Affiliations:

1. Faculty of Health Sciences, Collegium Medicum, Jagiellonian University
2. Laboratory of Clinical Skills and Medical Simulation, Ludwik Rydygier Collegium Medicum in Bydgoszcz Nocolaus Copernicus University in Toruń, Poland
3. Collegium Masoviense – College of Health Sciences, Żyrardów

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A. The idea and the planning of the study
B. Gathering and listing data
C. The data analysis and interpretation
D. Writing the article
E. Critical review of the article
F. Final approval of the article

Correspondence to:

Prof. Zbigniew Kopański MD PhD, Faculty of Health Sciences, Collegium Medicum, Jagiellonian University, P. Michałowskiego 12 Str., PL- 31-126 Kraków, Poland, e-mail: zkopanski@o2.pl

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I. INTRODUCTION

Every health care unit drawing up medical records is obliged to share it, in order to guarantee a continuation of processes: diagnosis, therapy and providing patients with essential materials, such as: medical devices or medical products. This obligation concerns also disposers and members of *Medical Rescue Team* (MRT), drawing up joint and individual records.

One of the most fundamental elements in process of treating patients, being in a life threating-state, is winning by a medical staff (taking care of patients in several places), as soon as possible, informations received by members of MRT through clinical examination. Fast data exchange is made possible through the application of electronic medical report and its sharing by using telemedicine systems. Master term towards this area is e-health, which essence is that it uses all kind of applications, that are designed for health-promotion, prevention of diseases, diagnosis, therapy and taking control, as well as enable sharing informations about health, via various technologies, for example Internet.

Telemedicine, called also *'medicine at a distance'* is one of the most contemporary way of performing services connected with health. This way combine elements of medi-

cine, telecommunication and computer science. The essence of telemedicine is creating possibility of sharing the key informations for a patient, which describe his or her health or carrying out often high-specialist consultations, independently of existing geographical barriers and location of a patient and a medical staff. This solution enables among other: diagnosis of illness, monitoring of physiological parameteres and patients' findings, as well as improvement of doing a procedure or consultating. Many of these aims can be reached without necessity of transporting a patient from one health care unit to another or even without a need to hospitaltization.

Telemedicine systems can be divided into 2 types: *offline* and *online*. *Offline* working systems allow to receive and analyze data in time convenient for medical specialist (asynchronously). *Online* systems guarantee real-time data transfer (specialist, to whom information was made available, analyzes it and sends it back immediately after its receiving - synchronously) [4,11,12]. Due to the possibility of real-time data transfer, telemedicine can be used not only by patients with chronic diseases, but also by sick people, who have suffered from sudden health deterioration [7].

Because telemedic solutions are being used in many different areas, they were divided into distinctive medical disciplines, such as telecardiology, teleoncology or telemergency. Due to the system functioning, telemedicine was also splitted into teletherapy, telesurgery, telediagnostic, teleconsultation and telemanagement [9,13].

Telemedicine systems can be used via Internet, Satellite, Integrated Services Digital Network (ISDN), Telephone or Cellular Network [7]. These services are addressed to the medical staff and patients [4]. Users of such solutions can only be medical professionals or medical professionals and patients (situated in different locations) [13].

II. ADVANTAGES OF TELEMEDICINE

As advantages of telemedicine considered are improvement of access to the services, results of carried out tests and medical documentation by sick people (especially those who live outside of larger cities), allowing access to the specialized consultation and services of medical institution, which offers narrower breadth of provisions, and also reduced number of unnecessary hospitalizations and transports (both patients and medical staff).

III. THE BENEFITS OF TELEMEDICINE

The benefits of using telemedicine include improving the access of patients (especially those living outside of large cities) to benefits, results of research and medical records, enabling specialist consultations and services through medical facilities offering a narrower range of services, as well as reducing the number of unnecessary hospitalizations or transports (both sick and medical workers). Telemedicine also allows to reduce the costs generated in both patient and administrative treatment. Data exchange between individual units entails the possibility of educating medical employees and raising professional qualifications by them, as well as improving the process of conducting scientific research. In addition, the use of telemedicine may also lead to an increase in the quality of medical assistance provided by enabling rapid diagnosis and implementation of appropriate proceedings in both planned and emergency cases.

Telemedical systems, users of which are ill people, has lead to enhancement of their feeling of security, resulting from them gaining more control over their health. (14-17). Application of telemedical solutions may lead to shortening of time necessary for making a diagnosis or its quick change after receiving a teleconsultation, as well as avoiding multiple repetitions of the same examination caused by shortage of information concerning results gained in other unit.

IV. BARRIERS FOR INTRODUCING AND DEVELOPING TELEMEDICAL SYSTEMS

Among barriers obstructing introduction and development of telemedicine we may enumerate a necessity of supplying by the medical units in proper hardware, enabling saving and sending data or conducting teleconsultation (in dependence on mechanism of system’s operation) (18-20). It requires vast financial supplies, concerning not only buying essential devices, but also unit’s provisioning with teleinformatic systems. Those systems must guarantee safety of processed data, as well as monitoring the access to them [8,18,21].

In order to enable the exchange of ideas between institutions it is necessary to strive to standardize the functioning of systems used by individuals [4,9,15,22]. The possibility of interoperating different systems (used by entities providing health-related services) in order to maximize the benefits from the secure exchange of necessary data, which will

result in the units creating information useful in the diagnosis and therapy processes, is referred to as *interoperability* [23.24]. Requirements enabling the implementation of this concept have been included in the *National Interoperability Framework* [25].

In order to make information available between individuals, it is necessary to apply standards that allow sending, receiving and interpreting data. The standardization process must also include the classification of diseases and the preparation of electronic documents. An exemplary standard for the exchange of medical data (made in digital version) is *Health Level Seven*, the rules defining the way of creating electronic medical documents are defined in the HL7 CDA standard (*Health Level Seven Clinical Document Architecture*), while one of the most popular standards for classifying diseases is ICD-10 [3].

A big limitation, which is directly related to raising funds, is the lack of covering the costs of a considerable part of telemedicine services from public funds. The exception are only teleconsultations between doctors: of the primary healthcare and specialist, as well as hybrid telerehabilitation [7,26]. The reason for the failure to refund most telemedicine solutions may be the lack of reliable studies, clearly proving the profitability and efficiency of telemedicine [4,14]. One of the elements deciding about the emergence of benefits from its application is the creation of systems attuned to the needs of future users [15].

The most important limitations in the implementation of telemedicine systems may include: the reluctance of medical staff and patients to use new solutions and communication barriers that may arise during the cooperation of specialists in the field of medicine or of sick people with IT specialists. The reason for the lack of willingness of the above mentioned groups to use this type of solutions may lay in the lack of knowledge about the benefits of telemedicine [11,18,24]. The condition for the implementation of telemedicine systems is the ability to handle them by staff and patients, which entails the need to organize appropriate training, and this will require a sufficient number of specialists with knowledge and experience in the field of telemedicine [20, 24, 28].

The limitation resulting from the way the telemedicine systems operate is the lack of direct contact between the medical worker and the patient, which may cause not only distrust of the patient, but also leads to the impossibility of conducting some research or collecting all information during the subject examination. In the traditional model of providing health-related services, a specialist can obtain information about a sick person using senses such as sight, smell, hearing and touch. in the case of telemedicine, the possibility of obtainig information is usually limited only to sight and hearing. [8,9,11].

Another condition necessary for the existence of telemedicine is the preparation of documents in an electronic version, which will enable quick sharing of data contained in them, but it often entails the need to provide uninterrupted access to the Internet or another link through which data is exchanged [4.8]. In the case of using telemedicine systems in emergency events, the condition for a successful operation of such a solution is the presence of a fast enough network through which data is sent, which will create the possibility of real-time communication [15].

A barrier significantly limiting the implementation and development of telemedicine systems are the unclear legal provisions regulating the issues concerning the provision of health-related services at a distance [4,8,16].

Telemedical systems are mainly used in medical areas where there are limitations in access to services, resulting for example from an insufficient number of specialists or in cases where speed of information and decision making is important for patients' health [13].

The most common life-threatening conditions faced by rescue teams are cardiological diseases, which are also the most frequent cause of death [19].

In a study analysing the medical documentation prepared at selected KRP stations in 2012, calls to patients with symptoms classified as”cardiological problems" ware accounted for 11. 4% of all *Basic Medical Rescue Team* and *Specialist Medical Rescue Team* calls. The majority of these calls concerned chest pain patients (56% in the case of P syndromes and 69% in the case of S syndromes) [30]. In the research carried out by Affyka and his co-workers, reports from patients with cardiovascular symptoms covered 15. 7% of all calls [31]. According to Guła and his co-workers, the most common reasons for the rescue team's disposal in the first code (alarm) were acute coronary syndromes and traffic accidents [32].

Due to such a high prevalence of cardiovascular diseases, telemedical systems implemented in the Medical Rescue System focused on improving the treatment of patients with life-threatening acute coronary syndrome [7,29,33].

Symptoms of ACS occur when there is a sudden disproportion between the amount of oxygen delivered and the needs of myocardial cells, the most common reason being the occlusion of the coronary arteries caused by the presence of a blood clot [34]. The ACS can include not only a heart attack, but also unstable angina. The occurrence of myocardial necrosis due to reduction of blood flow in the coronary artery (oxygen supply) is defined as NSTEMI infarction (without ECG elevation), whereas necrosis

caused by total vessel obstruction occurs in case of STEMI infarction (in which the ECG cuts off ST) [19].

The priority in the treatment of patients diagnosed with myocardial infarction (especially STEMI) is the fastest possible use of invasive and / or pharmacological therapy resulting in reperfusion, which requires immediate transport of the patient to the intervention cardiology center [9,29,34]. Any delays emerging from the occurrence of symptoms in the patient to perform invasive intervention (resulting in the vessel being cleared) significantly affect the prognosis and effectiveness of treatment of patients [34-36]. Such delays may occur in several stages. In the first place, they relate to the period from the onset of the patient's initial symptoms to the moment of his first contact with medical staff (e.g. from EMT). The speed at which the sick person or his / her relatives receive professional help is decisive at this stage. The second stage covers the time from the initial contact of the medical personnel with the patient until the initial diagnosis is made. During this period, the professional qualifications of medical staff are of the greatest importance. The last stage during which delays may occur covers the period from the moment of diagnosis to the patient's reperfusion (often due to invasive surgery). At this stage crucial are not only competences of MRT members, but also an efficient transport of a patient to the right health care unit [35,64]. For that reason a big meaning has not only a quick diagnosis of MRT members, but also to make possible the direct transport to the health unit, which is equipped with a circulatory practice of hemodynamics on the interventional cardiology center [35]. To this purpose/ aim, a teletransmission system made by MRT was designed and implemented at the ECG call point, which also enables tele-consultation with a cardiology specialist. The use of such a solution makes it possible to transport the patient with diagnosed ACS (Acute Coronary Syndrome) directly to *Interventional Cardiology Unit* (omitting the nearest *Emergency Department*) and (with it connected) shortening the period from diagnosing the disease to releasing the coronary vessel.This system allows to reduce the total time from the appearance of the initial symptoms by a patient until effective invasive therapy [16,37,38].

The need to implement a system created to optimize the patient transport process is supported by persistent high prehospital mortality among people with diagnosed/ identified heart attack [19, 35].

V. HOW THE ECG TELETRANSMISSION SYSTEM WORKS IN AMBULANCES

In the case of symptoms of ACS, which include retrosternal localized pains with very high intensity, which may be crushing, stinging, squeezing or chInterventional Cardiology Unitng, with possible accompanying radiation e.g. to the left upper limb or mandible, the sick person or their loved ones should immediately call for professional medical help. The medical dispatcher who receives the notification, deciding on the team's disposal fills out and forwards the departure order card. The rescue team arriving in the field first performs a diagnostic and physical examination of the patient. During the collecting of the medical history obtained in sequence are: information about the symptoms occurring in the patient, existing allergies (especially to medication), used medications and diagnosed diseases. In addition, during the diagnostic examination, the time of the last meal consumed is recorded, as well as the circumstances leading to the appearance of symptoms, e.g. stress or physical exercise preceding the event [66]. An inseparable element of physical examination in patients reporting chest pain is a 12-lead ECG. The finding of a characteristic change in the ECG in such a patient authorizes the emergency team to pre-diagnose ACS [20,39].

The task of EMT members is not only to carry out the necessary tests, make a diagnosis and transport the patient safely to the hospital, but also to perform appropriate medical procedures and to implement proper pharmacological procedures that have a significant impact on the effects of therapy [19,28].

Medicines, which can be used in patient with suspected ACS by primary teams (consisting of paramedics and nurses) include: morphine, medical oxygen, nitroglycerin and acetylsalicylic acid. In addition, the preparation avaiable to paramedics is unfractionated heparyn [39,40]. The decision to give medicines undertake the team leader after eliminating possible contraindications [19].

In case of initial determination of ACS or the presence of non-specific symphtoms suggesting, for example, cardiac arrhythmia, it is possible to use the ECG teletransmission system. Electronic record carried out with a defibrillator (constituting a transmitting station), is transmitted by a Bluetooth connection to the mobile phone equipped with appropriate software and located in ambulanse.Then it is transferred to the server at the *Medical Receiving Station* located in the on-call hemodynamics laboratory via wireless mobile network. The values of the

patient's physiological parameters measured by the defibrillator may also be transmitted. From the server, the data goes to the cardiologist on call via e-mail (which is accessed by a computer) and / or printout. The sound signal informs about the transmitted data, e.g. in the mobile phone in which the receiving station is provided [9,15, 34, 37].

Teletransmission carried out by MRT ECG was combined with the possibility of teleconsultation with a specialist evaluating the record. The connection is made by the leader of MRT. During the conversation, a cardiologist gaining all the necessary information about a patient (including values of the physiological parameters of the patient, if they were not subject to transmission), establishes with a team the following way of proceeding, qualifying the patient for an invasive surgery. The result of this teleconsultation may be not only immediate transport of the patient to *Interventional Cardiology Unit*, but also the order for the use of additional medicine by nurses or paramedics, which makes the ECG teletransmission system of particular importance in case of basic teams [19,20,28, 33, 40].

If the patient has been qualified for the invasion therapy, MRT transports him directly to the homodynamic laboratory to which his data was previously transmitted. Thanks to the maintaining of communication, *Interventional Cardiology Unit* staff can prepare for the patient's reception [16, 34]. After transporting him to MRT laboratory, provides medical employees a MCR card to the workers where (except for the data characterising the patient's condition) information about the ECG teletransmission procedure has been recorded. Decisions on further therapy are made by the medical staff of the hemodynamic laboratory [2].

Nowadays ECG teletransmission can be performed using the following systems: *LIFENET and ZOLL Data Relay System* [5,20]. According to the European Society of Cardiology recommendation, the transfer of ECGs to the receiving station by Medical Rescue Team should not take more than 10 minutes from the patient's initial contact with the emergency staff, while the telephone conversation should take up to 5 minutes [28].

The use of the ECG teletransmission system brings benefits not only for the patient (allowing the specialist to quickly diagnose at a distance and decide how to proceed, which minimizes the time necessary to implement the most effective therapy in the patient), but also for the ambulance crew (enabling in the case of the basic team, increase in the scope of pharmacological management conducted by her and the extension of specialist knowledge allowing her to improve her professional qualifications) [16, 20,28, 37].

In Poland, the system was first used in emergency service units in 2001 [16]. Created primarily to support the conduct of medical rescuers and nurses working in Medical Rescue Team P, it is now increasingly used as a standard procedure regardless of the type of team [9, 29, 33].

The pattern of the ECG teletransmission system is shown in Figure 1.

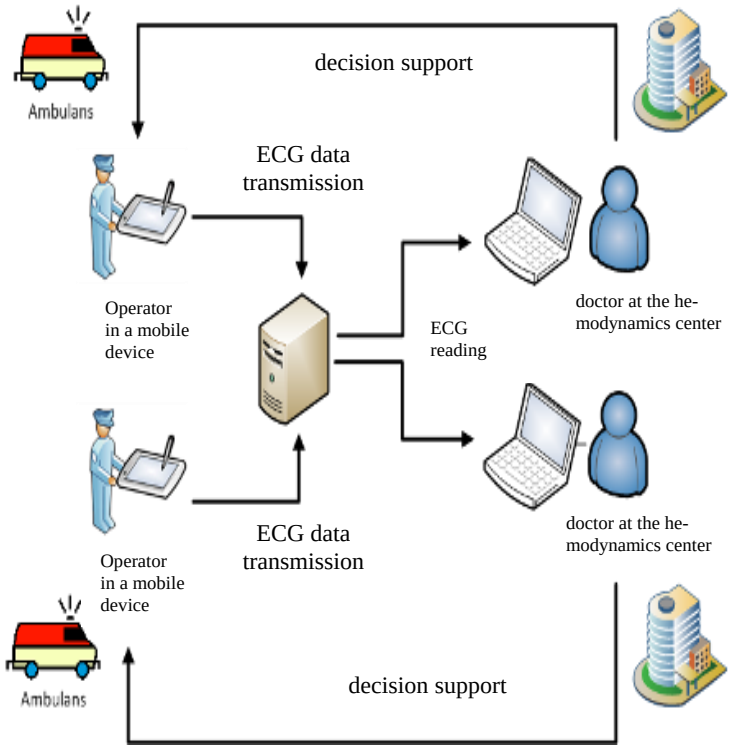

Figure 1. The scheme of the ECG teletransmission system [42]

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[42] Małopolska dba o zdrowie: Schemat działania teletransmisji ECG. Adres: https://www.profilaktykawmalopolsce.pl/aktualnosci/541-system-teletransmisji-ECG-juz-dziala-w-malopolsce (dostęp w dn. 05.06.2018).